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The Photo Miniature

VOLUME XVI : MAY, 1923 : NUMBER 189

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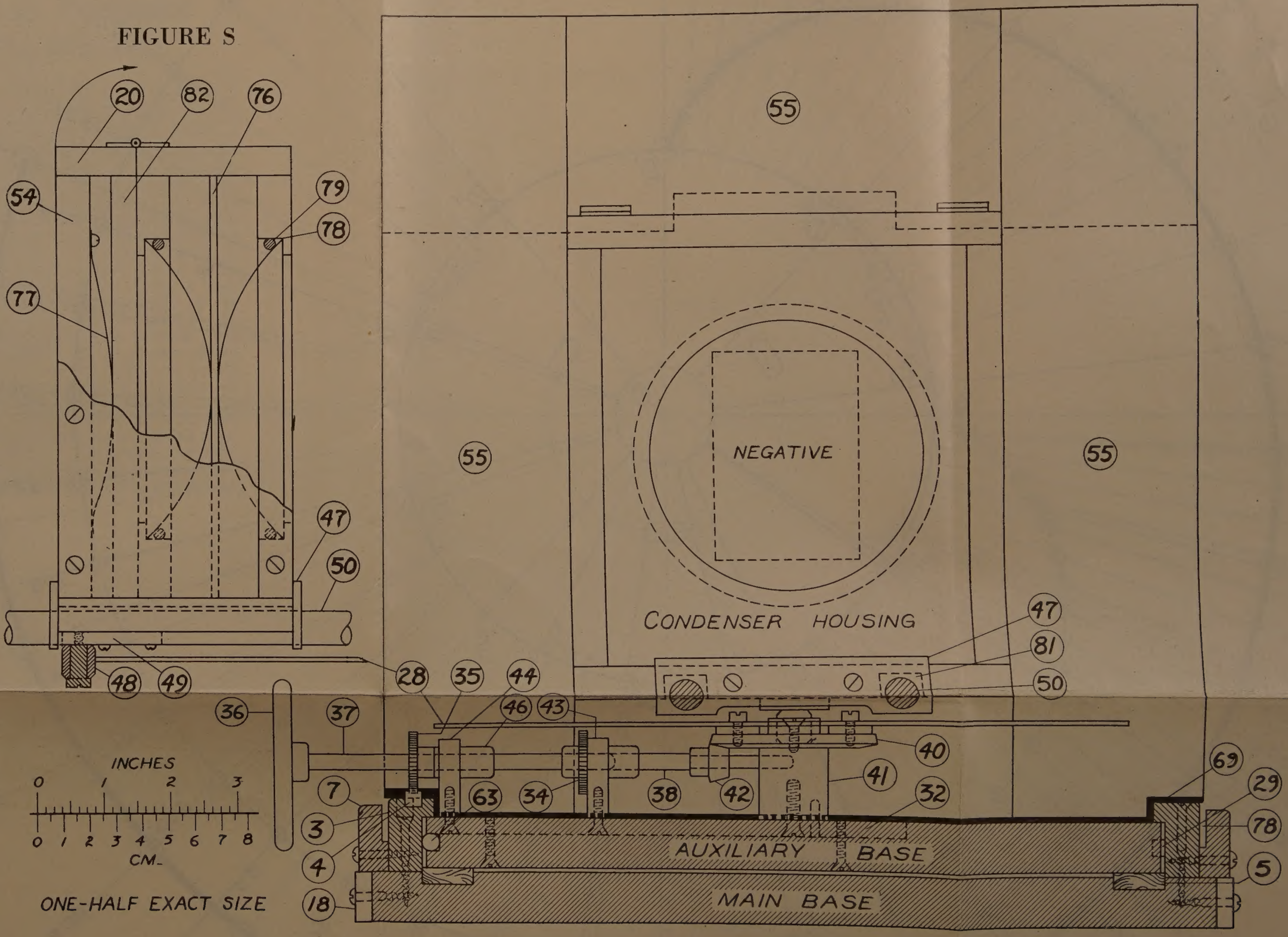
FIGURE S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AUXILIARY BASE
MAIN BASE
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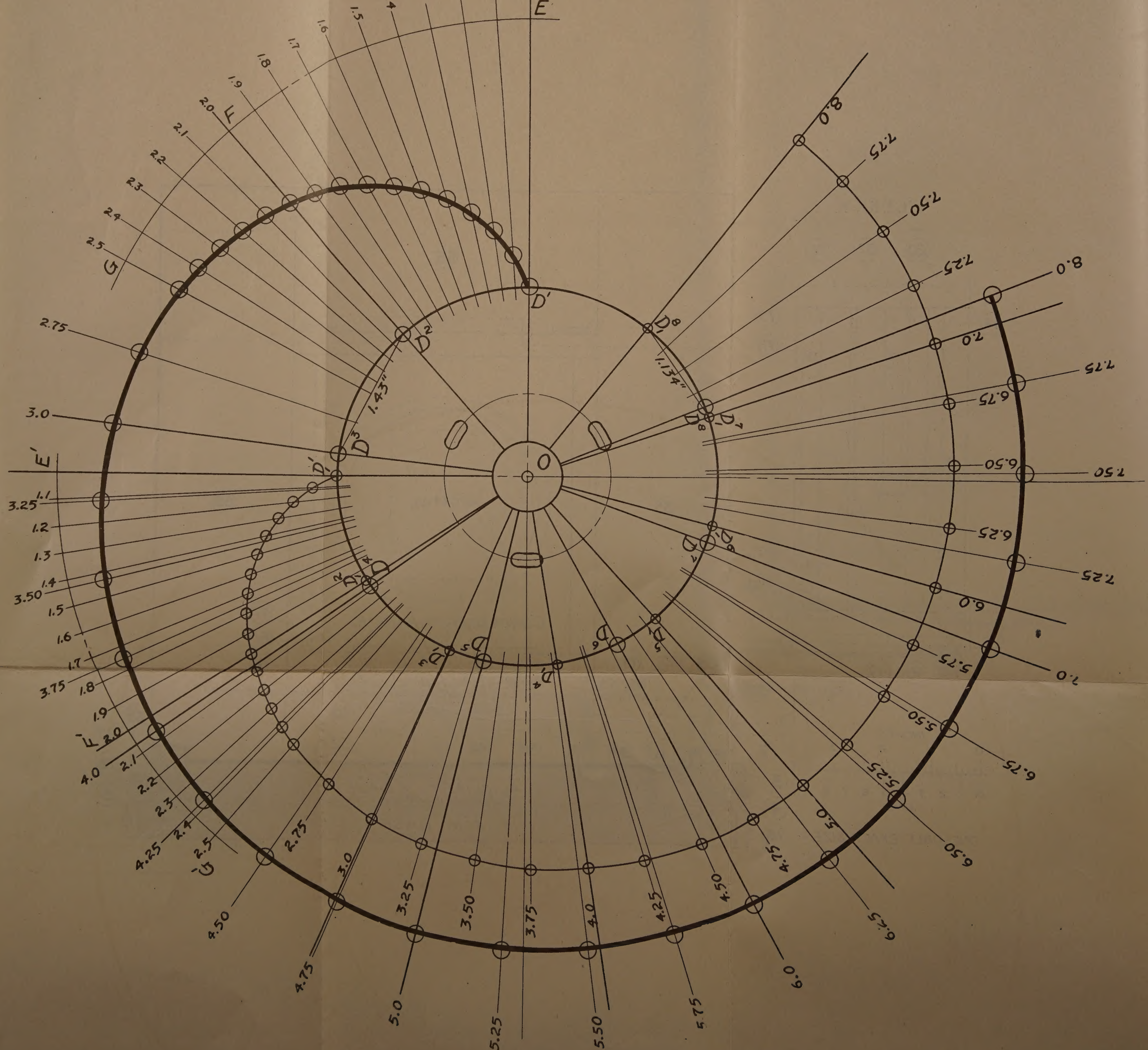
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FIGURE T

The Photo-Miniature
A Magazine of Photographic Information
EDITED BY JOHN A. TENNANT

Volume XVI May, 1923 Number 189

Making an Automatic Focusing Enlarger

The making of large prints from small negatives is undoubtedly the most interesting problem in photography today. It is, in fact, today's preparation for the photography of tomorrow, when compact cameras of the Cine Kodak, Ica Kinamo and Sept type, instantly adjustable for rapid motion or individual exposures, will replace the existing hand and pocket cameras, and all our negatives will be small negatives—no bigger than a man's thumb-nail. Coming events cast their shadows before. For almost every serious purpose we need prints at least 5 x 7 to 8 x 10 inches in size: e. g. for portfolio, illustration, process reproduction, record and exhibition use. Until recently we have used cameras and equipment producing negatives of the size required in the print, obtaining the print by the method familiarly known as contact printing. But the world-wide demonstration, on the motion picture screen, that large prints of superb quality can be obtained from negatives no larger than 1 x ¾ inch, has done its work. As one result seventy-five per cent of the negatives made by amateurs today are made with the perfected miniature or pocket camera, giving negatives generally smaller than 2¼ x 3¼ inches. Similarly, among professional and commercial photographers the tendency grows, of making small negatives and delivering prints therefrom as large as their intended use demands. Thus we have come to see that it is no longer necessary to make a negative as large as the print desired, since the quality of the print depends wholly on the quality of the negative and not on its size, or on the method employed in making the print. Hence the vital interest and significance of the methods available for the making of large prints from small negatives, commonly spoken of as enlarging methods.

Old and New. These methods have been discussed at length in many issues of The Photo-Miniature: e. g. Nos. 16, 35, 75, 100, 144 and 164, all now out of print. They served their day and purpose by showing how to get large prints from small negatives by projection printing (enlarging), fully equal in quality to the large prints obtained directly from large negatives by contact printing. That these enlarging methods were more troublesome than the making of contact prints was indisputable, but the convenience of the small negative and the possibilities of modification and control in the enlarging process more than compensated for the disadvantages. Within the past year or two, however, enlarging methods have been, so to say, revolutionized by the introduction of special apparatus by which the bothers and difficulties peculiar to the earlier methods have been completely eliminated, and the making of large prints from small negatives (enlargements) is as simple as the making of contact prints.

The Heart of the Difficulty in the oldtime methods was the obtaining of a sharply defined image of the size or degree of enlargement desired. This depended, and still depends, upon a certain and accurate adjustment of the relative positions of the lens of the enlarging apparatus and the negative, and of the lens and the easel or sensitive paper on which the enlargement is obtained—an optical problem, solved by the use of lens calculations or by tedious trial and error. What happens is that with every change in the size or degree of enlargement desired, the pair of distances of the negative and of the sensitive paper respectively from the lens must be altered according to a definite rule governing their relation. Enlarging, reduced to its simplest terms, is based upon placing the lens between the easel and negative at certain definite positions with respect to the positions occupied by the easel and negative to secure different degrees of enlargement in the projected image. When, by repeated and bothersome adjustment this correct relation of the distances separating lens and easel and lens and negative is secured, then we get a sharply defined image of the size desired. With the automatic enlarging apparatus of today this adjustment is obtained by a simple movement of one part of the apparatus, by which the projected image is made to grow or shrink at will and yet is always maintained in perfect focus or definition. This means the elimination of all the trouble and fussing encountered in the earlier enlarging methods, together with complete control of the elements or composition of the enlarged image. The device by which this simplification of enlarging is effected consists essentially of a cam mechanism which so coordinates the movement of the parts of the apparatus as to automatically produce the relation of lens distances ensuring a sharply defined image at any desired degree of enlargement within the capacity of the apparatus in use.

Automatic Enlargers. The credit for the introduction of this improvement is due to the Eastman Kodak Company, and as the first commercial examples of this type of enlarger we have the Kodak Auto Focus Enlarger and Projection Printers, now coming into general use. Other examples are the Rexo Automatic Enlarger (Burke & James) and the Forsberg, with one or two European models not obtainable here. In the following pages Mr. Chester A. Kotterman describes and illustrates the design and construction of such an automatic enlarger. The special apparatus he describes may be made to serve a double purpose and so has a larger capacity than any of the commercial models. In the first form, as set forth in detail, it is a self-contained automatic focusing enlarger for prints up to 8 x 10 inches, Fig. C, and may be used in any room illuminated with daylight or artificial light, a convenience to the amateur who has no darkroom. In the second form suggested, the enlarger may be converted, by certain adjustment of its parts, into a projection printer, as shown in Figs. D and Q, where Fig. D gives a side view and Fig. Q an end view, giving enlargements larger than 8 x 10 inches. In this form, however, it is no longer a self-contained unit, but is used with a separate and independent easel and requires a darkroom or enlarging room for its operation. In either form the lens employed in making the original negative is used in making the enlargement.

Note, in passing, that in speaking of degree or times of enlargement in these pages, the reference is always to linear dimensions, not to increases of area. Thus a 4-times enlargement of a negative 2¼ x 3¼ inches gives an enlargement 9 x 13 inches.

Enlarging Fundamentals. As enlarging is simply an application of certain well-known optical laws or principles, it will be well at this point to consider briefly two fundamentals in enlarging, so that the principles underlying the designing and construction of an enlarger will be clear to the reader.

Focal Length. In the development of the cam mechanism which is the vital factor in an automatic focusing enlarger, it is essential to know, very precisely, the equivalent focal length of the lens to be used as part of the apparatus. With the design for an enlarger given in this issue, full-size diagrams (Fig. T) are provided for the construction of two cams calculated for use with miniature camera lenses of 3″ and 3½″ equiv. focus respectively. But it will not do for the reader to assume that the lens on his camera, listed as 3″ or 3½″, will work with the 3″ or 3½″ cam shown in the diagram. This will not be the case unless the equiv. focus of the reader's lens is exactly the same as the equiv. focus of the 3″ or 3½″ lenses mentioned in the text. The focal lengths of lenses listed in manufacturers' catalogues are approximate only; on careful measurement the actual equiv. focus of almost any one will slightly differ from the approximate figure used to classify the lens in the makers' list. In ordinary photographic work this slight difference need not be considered, but it is of prime importance in the development of the cam required in the automatic enlarger. Hence the first thing to know is the actual equiv. focus of the lens to be used in the enlarger. If it is not exactly the same as the 3″ or 3½″ lens mentioned in the text, the reader must develop a cam fitted to his lens, following as a guide the method of laying out a cam described on other pages.

Finding Equivalent Focus. The simplest way of finding the actual equiv. focus of the lens on your camera is to write to the maker, giving the number of the lens and asking for the precise information desired. Or any lens or camera repairer, possessing an optical bench or long bellows camera, can by a careful test of the lens supply the exact focal length in millimeters. Or you can find it for yourself by the following method, due to the late T. R. Dallmeyer. Remove the back from the camera and set up a groundglass or focusing screen at right angles to the optical axis of the lens. Focus on some very distant object as a cloud or prominent object in a distant view. Measure from the image side of the groundglass along the optical axis of the lens to any convenient point on the lens mounting, calling this distance a. The point of intersection of the focal plane with the optical axis of the lens is known as the back focal point designated F. Now reverse the lens in its mounting, or reverse the position of the camera, retaining the relative position of the lens, camera and screen. Focus on the same distant object and measure similarly the distance b from the image to any convenient point on the lens mounting. This locates the front focal point F^1. Next focus on an object three or four estimated focal lengths away. Measure the distance from the object to the point on the lens mounting used for b, designating this measurement as c; likewise the distance from the object to the other point a, designating this distance d. Let f be the equivalent focus of the lens. Then $f^2 = (c - b)(d - a)$ and by substituting the distances measured for a, b, c, and d in this equation it becomes an easy matter to arrive at the value of f, which is the exact equiv. focus of the lens used. This method, while not as simple as some others in the books, is an exact method; and errors in determining the various distances least affect the result when the image and object are of equal size, that is, when the distances *c* and *d* are equal. It is a good plan to repeat these measurements several times, obtaining an average value of f. With this knowledge of the exact equiv. focus of the lens on your camera the development of the cam for the enlarger may be carried out with complete confidence as to results.

Conjugate Foci and Enlarging. The other fundamental is a knowledge of the law of conjugate foci as applied in enlarging. The word foci is the plural form of focus and conjugate foci simply means a pair of foci joined together or related. The conjugate foci used in enlarging are the distances of the negative and sensitive paper respectively from the lens. These distances depend on the focal length of the lens and change with each different degree of enlargement. Their actual length is determined by the focal length of the lens; their relative length by the degree of enlargement, following a definite rule.

In making a copy of the same size as the original the two conjugate foci are exactly the same and each one is twice the focal length of the lens. This establishes an important rule in photographic optics, viz., that the distance separating an object and a fullsize image of that object is equal to four times the focal length of the lens used. When we make an enlarged image of an object, the conjugates differ according to the degree of enlargement, but according to the following rule. The distance between the sensitive paper or easel and the lens equals the focal length of the lens *multiplied* by the degree of enlargement plus one focal length, and this distance is known as the major conjugate. Thus with a 3″ lens and 2-times enlargement it is $3 \times 2 + 3 = 9$ inches. The distance of the negative from the lens equals the focal length of the lens *divided* by the degree of enlargement plus one focal length, and this distance is known as the minor conjugate. Thus $3 \div 2 + 3 = 4\frac{1}{2}$ inches. With these simple rules one may calculate the conjugate foci or lens distances required for any desired degree of enlargement and, in the oldtime methods of enlarging, either this was done or one made use of the convenient Table of Conjugates for Enlarging to be found in any photographic yearbook. When these various combinations of major and minor conjugates or lens distances are brought about simultaneously by some mechanical means we have automatic focus enlarging. This is effected in the apparatus which, from this point forward, is described by Mr. Kotterman. EDITOR.

Hypothetical Enlarger. Before considering in detail the actual design and construction of an automatic focusing enlarger, let us formulate a hypothetical device so as to lay down the fundamental factors to be considered in an apparatus of this character.

Suppose we mount an easel at one end of a base or platform. On top of this base let us place a smaller base free to slide back and forth between guide rails on the supporting base. If we mount the miniature camera, whose lens we are going to use as the enlarging lens, on this auxiliary base, we may alter the distance between the easel and the lens by sliding the auxiliary base on the main base. If now we could move the negative holder with respect to the lens while racking in and out the lens with respect to the easel, the whole problem of automatic focusing for any degree of enlargement would be solved.

Let us now refer to the illustrations running with the text for the better visualization of such an enlarger. In the references which follow, the specific part or detail of the apparatus spoken of is designated by a numeral within brackets, the illustration or diagram to be consulted being designated as Fig. A, B, C, or other letter of the alphabet. Every detail or specific part of the apparatus always carries the same numeral, but sometimes the reference is made to this detail in several diagrams. Note that Fig. T will be found on the folded insert facing first page of the text, while Fig. S is given on the first page of this insert. All other Figs. are given in the text pages.

The Hypothetical Apparatus Visualized. Fig. A is the main base of the apparatus supporting at the left end an adjustable easel, or in this case an enlarging back (8) Fig. B, for the sensitized material; sliding on top of the main base is another and smaller base (14) Fig. B carrying a fixed lens bracket (15) Fig. B; and a superposed negative holder (17) Fig. B capable of moving relatively to the main base and the auxiliary base.

Suppose we attach a long toothed rack (4) Fig. A, to one of the guide rails which fix the path of travel of the auxiliary base, and suppose further we have attached to the auxiliary base a rotating axle on which is a small gear wheel engaging with the teeth in the rack. By means of this rack and pinion, similar to those employed on view cameras, the auxiliary base is made to move forward and backward on the main base. If we attach a bevel toothed wheel to the rotating axle and mount an upright spindle carrying a similar bevel toothed wheel on the auxiliary base, a rotary motion will be imparted to the bevel gear on the spindle at the same time the auxiliary base is sliding on the main base. If we then attach a cam shaped disc of metal to the bevel gear on the vertical spindle, the edge of which presses against a stud fixed to the negative carrier, the latter will move with reference to the lens while the lens is moving with respect to the easel, and the shape or contour of the cam, pressing against the stud, determines the degree of movement of the negative holder; and the coordination of the several movements will

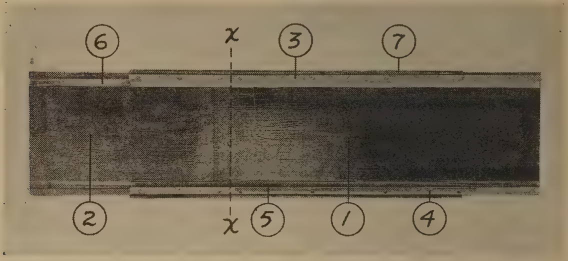

Fig. A

determine the degree of magnification of the negative image. This in substance is what is done with the enlarger here described.

Nomenclature. The automatic enlarging apparatus here described consists of the following essential parts:

1. The main base or support for the apparatus. Figs. A and B.
2. The enlarging back, carrying the focusing screen, bromide paper holder or plate holder and the roller ends of the bellows. (8) Fig. B.

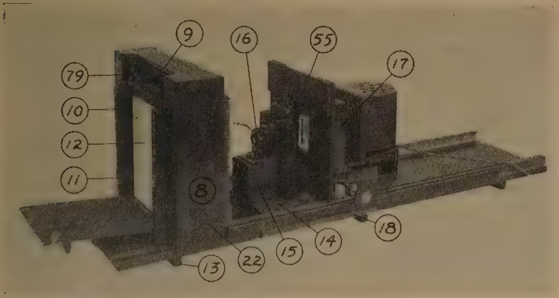

Fig. B

3. The auxiliary base (14) Figs. B and F, which supports—
   a. The cam mechanism producing automatic focusing, Fig. G.
   b. The lens and camera bracket. (Chair device (15) Figs. B and L.)
   c. The negative and condenser carrier, (17) Fig. K and (65) Fig. L.
   d. The lamp house or illuminator, (57) Fig. K.

The Main Base, Figs. A and S (which is a cross-sectional view of the apparatus, half full-size, looking towards the easel end) consists of two wooden sections (1) and (2) hinged on the line x—x. (2) the shorter section is 20¼″ long and (1) the longer section is 31″; and their width is 12⅜″. Each section is made of four strips of poplar wood ⅞″ thick glued together and fitted with tongue and grooved batons at the ends, with three cleats (13) Fig. B, underneath to prevent warping. The base is held in a continuous flat surface by means of the brass strips (18) Fig. B. These brass strips have another function which will be explained later. The guide rails (3) Figs. A and S extend nearly the entire length of each edge of the main base to fix the path of travel of the auxiliary base. They have the cross-section and dimensions shown in Fig. S. They are screwed, one on each side of the main base and parallel to its edges. Like the main base the guide rails are made in two sections with the joint at the same point as the hinged line of the main base. See Fig. A. The guide rails extend the entire length of the longer section (1), but they only extend 10″ from the dividing line on the shorter section.

Before these guides are permanently attached to the base, two grooves 3/16″ deep and ¾″ wide are cut in the main base adjacent each guide rail. These grooves, which reach the entire length of the main base, are then filled with hardwood strips of the same length as the guide rails and projecting above the surface of the base 1/16″, (5) Fig. A and (5) Fig. S. The raised surface of these strips eliminates nearly all sliding friction between the auxiliary and the main base. Of course, the guide rails and raised strips are integral with each section of the main base so that when this is flat they appear continuous. The guide rails and the inserts do not extend the full length of the shorter section of the base but leave an open part (6) Fig. A of the grooves at one end, as indicated. These grooves afford a means for attaching the enlarging back to the base in a slightly movable manner so it may be adjusted for critical focusing, as explained later.

The Enlarging Back (8) Figs. B, E and O consists of a main rectangular wooden frame, like a box without top or bottom, 4½″ depth, 15″ wide and 15 3/16″ high, made of ½″ poplar wood. The back edge of this rectangular box is fitted with a frame the opening of which corresponds to the opening of the bromide paper holder. The holder is an 8 x 10 Eastman combination bromide paper and plate holder, or single book holder equipped with nesting kits from 3¼ x 4¼ to 8 x 10. [The size of the plate holder determines the more important dimensions of the apparatus. That is, if an 11 x 14 holder were desired instead of the 8 x 10, as here described, then the optical axis of the lens, the center of the negative carriage and the center of the illuminator would have to be raised a greater distance from the surface of the main base than would be necessary when using the 8 x 10 holder.] The holder is illustrated in Fig. R. The top back edge of the frame is cut away as at (9) Fig. O to provide clearance for the fingers when inserting and removing the plate holder.

The plate holder is held against the framed opening of the back edge of the rectangular box by means of two strips of wood, one on each vertical edge of the frame, as indicated by (10) Figs. B and O. These L-shaped pieces of wood contain flat bowed springs (11) Fig. B which force the holder against the frame, and the opening between the inner surface of the strips and the back is such that when the focusing screen (12) Fig. B is in place the holder may be inserted between it and the back of the enlarging back, as is ordinarily done with view cameras.

The focusing screen (12) Fig. B is simply a thin wooden frame similar to a picture frame. It has a recess in which fits the sheet of ground glass and may or may not be fitted with a hinged back. The ground glass should be of a very fine grain which will permit of sharp focusing. Care must be taken to insure that both the focusing side of the ground glass and the sensitized surface of the enlarging material, when in place in the plate holder, register exactly in the same plane, otherwise the sharp image as seen on the ground glass may not be sharp when the plate holder is inserted.

Critical Focusing. The adjustment of the enlarging back to secure critical focusing is accomplished in the following manner. Two hardwood strips (72) Fig. O are screwed to the bottom surface of the rectangular frame. These strips are thick enough to project about 1/16″ above the surface of the main base, which prevents the bottom of the rectangular frame sliding directly upon the main base, thus reducing the friction between these to a minimum. The strips should be attached even with the front edge of the frame but may extend from the back edge about an inch to give greater stability and they should slide freely in the unfilled portions of the grooves of the main base. One end of the threaded axle (71) Figs. C and O, ⅜″ in diameter and 7″ long rotates in the brass plate (70) Fig. O which is screwed to the bottom edge of the frame. A small brass plate (19) Fig. C having a threaded hole through which screws the axle (71) is attached to the end of the main base. A hand wheel is fastened firmly to this axle, and by turning it the enlarging back is moved very slowly back and forth in the grooves of the main base, thus affording a means for very sharp focusing.

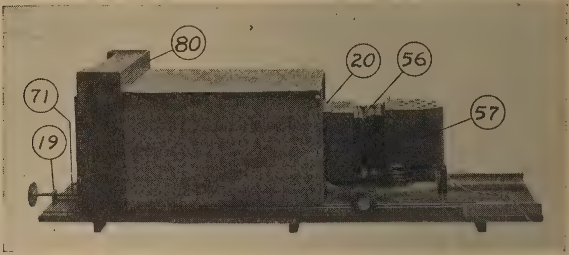

Fig. C

For Diffusion Effects. A box-like frame (25) Fig. E constructed of ¼″ wood with inside dimensions as shown in Fig. O is fitted within the main rectangular frame of the enlarging back. This frame is not necessary but may be found convenient if it should be desired to make diffused focus enlargements through bolting silk. Light wooden frames may be covered with the silk, and these frames fitted nicely on the inside of the box-like frame; thus they may be moved back and forth in this inner frame in front of the enlarging material and the adjustment possible provides most any degree of softness or diffusion of the projected image.

The Bellows. A study of Fig. E discloses the manner in which the parts of the bellows are assembled and attached to the enlarging back; and Fig. C shows the enlarging back complete with the bellows extended. The bellows consists of three opaque window shades rolling up on spring rollers attached to the sides and top of the enlarging back with the main base as the fourth side. The opaque window shade material, preferably of a dull black color, is 36″ long. The width of the two side curtains is 12″ and the top edges of these come even with the top surface of the rectangular frame of the enlarging back and the lower edges just reach the bottom of the grooves (78) Figs. Q and S formed by the guide rails and the extra pieces (7) Figs. A and S. The two side rollers are held in place by small brass strips (79) Fig. B screwed to the top and bottom of the enlarging back extending far enough out so the shades will roll completely up without touching the sides of the frame.

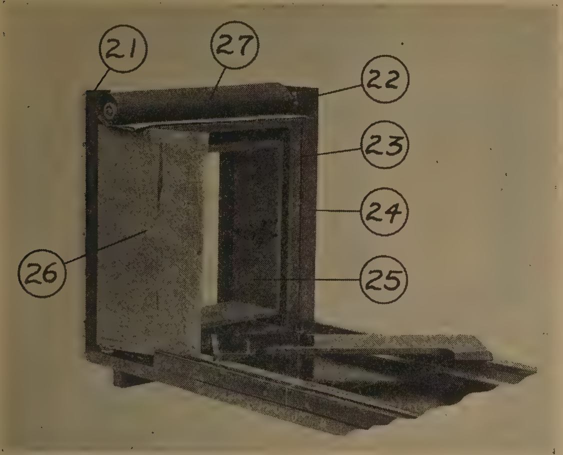

FIG. E

Two strips of ½″ wood (21) Figs. E and O are next screwed even with the back edge of the enlarging back and even with the bottom, but projecting above the top of the frame with sufficient width that when two similar pieces (22) Figs. B and E are screwed at right-angles to the two pieces just mentioned they will clear the shade when it is rolled up. Fig. E shows one of these side pieces removed. Two more pieces of wood (24) Fig. E of the same height as the enlarging back are attached to the pieces (22) Fig. E. The width of these pieces, however, is such that they do not quite touch the side of the rectangular frame comprising the enlarging back but leave a 1/16″ space, as indicated at (23) Fig. E. It will be apparent from the foregoing description that the three pieces of wood attached to each side of the main frame of the enlarging back form a housing which completely incloses the side curtains of the bellows, and the ends of the bellows members slide through the spaces between the housings and the rectangular frame. As the bottom edges of these housings are even with the bottom of the main frame of the enlarging back which is raised about 1/16″ above the surface of the main base, they do not slide on the main base. Strips of black felt, whose lower edges press against the main base may be attached to the lower inside walls of the housings, thus effectively blocking out any light that might leak in along the lower edges of the housings.

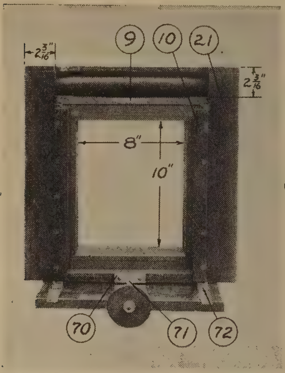

Fig. O

The top curtain (27) Fig. E is 13″ wide so its roller may be held by little brass plates screwed to the inner surface of the side housings. A housing similar to those on the side of the enlarging back is fitted on top of the main frame. In Fig. E the top of this housing has been removed and is seen lying on the main base. Its back edge is cut away as at (9) Fig. B, providing ample clearance for the insertion and removal of the plate holder and focusing screen. Another piece of wood (80) Fig. C is attached to the front edge of the top piece of this housing and like the two side pieces (24) Fig. E it leaves a 1/16″ space for the top curtain to pass through.

The opaque shades forming the bellows members should be made up with a 1/2″ stitched edge along either side which greatly stiffens the material. The rollers are ordinary window shade rollers cut down to the proper lengths. The little "dogs" or pawls which drop in notches in the end of the rollers, when they are hung horizontally at a window to hold the curtain at any point, should be removed before the rollers are permanently installed or they may be put out of commission quite easily by pressing a bit of gum or wax on them after they have been moved as far as they will go from the notches.

The two side curtains pull out directly through their slits into the grooves (78) Figs. Q and S. The top curtain pulls out through its slit, and as the side curtains are even with the top surface of the main frame of the enlarging back, the top curtain rests on the upper edges of the side curtains.

The housings are necessary to prevent light leaking into the inside of the bellows at the enlarging back end of the apparatus. This construction affords a very simple yet serviceable bellows, light tight enough for use in a room illuminated by artificial light, but it may be made strictly light tight, however, by throwing a focusing cloth over it during exposures.

Before leaving the subject of the enlarging back and the bellows, it may be remarked that these two items need not be built if it is desired to limit the construction of the apparatus to a projection printer. As was pointed out earlier, the apparatus here described serves a dual purpose and to use it as a self-contained unit it is necessary to build the enlarging back and the bellows. It is obvious too the construction of the shorter section of the main base may be eliminated if one is going to confine the construction to a projection printer.

The Auxiliary Base, Figs. F and G, is constructed of four pieces of ⅞″ poplar wood glued together with tongue and grooved batons at the ends. It is 10¾″ wide and 19″ long. Its width is ⅛″ less than the distance between the inner surfaces of the guide rails of the main base. See Fig. S. A ¼″ brass rod (63) Figs. G, K and S is set in a groove in one side of the auxiliary base and two brass springs (29) Figs. F and S are set in the other side. The surface of the brass rod projects about 1/32″ beyond the edge of the base and the two springs on the other edge keep the base pressed against one guide rail, thus reducing friction and maintaining perfect alignment. Having constructed the auxiliary base and fitted it to the guide rails so that it slides freely back and forth between them, the next step will be the construction of the cam mechanism.

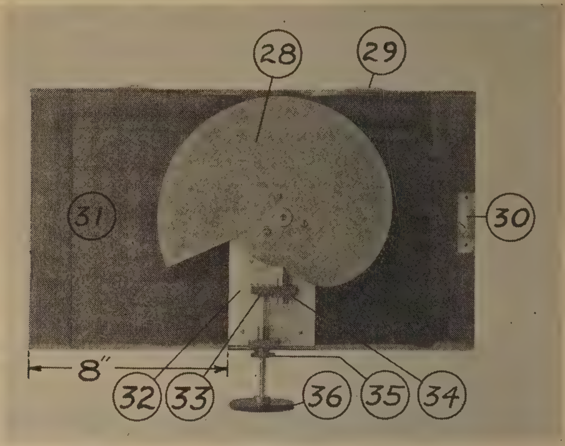

FIG. F

Lens Foci and Enlarging. Before taking up the details of cam construction, it may be well to turn back and re-read what was said about the necessity of knowing precisely the equiv. focus of the lens to be used, and the part played by conjugate foci in enlarging. The importance of a clear grasp of these two factors cannot be over emphasized. The accurate and smooth operation of the cam mechanism and its efficiency in automatic focus enlarging are wholly dependent upon the fitting of the cam to the precise equiv. focus of the lens. This being known or determined by careful measurement, we are now ready to consider the construction of the cam, and all references to focal lengths hereafter are to be read as meaning the exact equivalent focus of the lens in use.

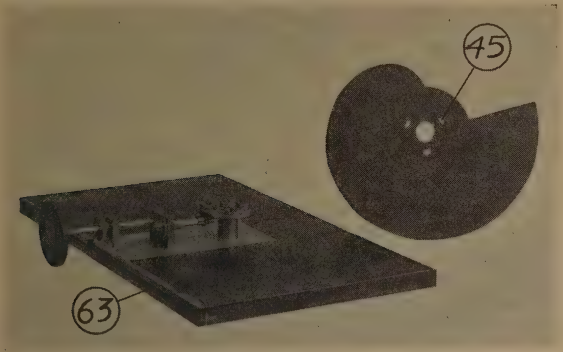

FIG. G

We will deal with two cams, Fig. T, one being termed a 3″ cam because it has been designed for use with a lens listed as 3″ focal length, and the other a 3½″ cam for use with a lens listed as 3½″ focal length. It is understood, of course, that these cams cannot be used with any lens listed as a 3″ or 3½″ lens, but only where the 3″ lens has an exact equiv. focus of 2.874″ and the 3½″ lens an exact equiv. focus of 3.63″. If you find that your lens does not have an equiv. focus equal to either of these two above mentioned values, it will be necessary to work out individual values and develop a cam to fit your lens by following the method given on a later page.

Theory of Automatic Focusing. We have seen that the distance from the easel to the lens follows a very simple law: degree of enlargement times the equiv. focus of lens plus one focal length. For example, suppose our enlarging lens has an equiv. focus of 3.63″, and we desire to make an enlargement of 2-times. Applying the rule just stated: 2 x 3.63″ + 3.63″ = 10.89″. For a 4X enlargement it would be 18.15″; and for a 6X enlargement it would be 25.41″. An examination of these figures discloses an interesting fact. Starting with a 1X enlargement, or where the enlargement is the same size as the original (at the major conjugate foci points of the lens), the distance between the lens and the easel is equal to the addition of one focal length to each succeeding degree of enlargement; that is, 1X enlargement equals 7.26″; 2X = 10.89″; 3X = 14.52″; 4X = 18.15″; 5X = 21.78″; and 6X = 25.41″. In other words the distance between the lens and the easel varies in a direct ratio for any degree of enlargement. If this or a similar ratio were true of the varying distances between the lens and the negative, it would be quite simple to design an automatic focusing device. Let us see how the negative distances compare with the easel distances.

The distance of the negative from the lens is equal to the equivalent focus of the lens divided by the degree of enlargement plus one focal length, which gives for the degrees of enlargement used above: 1X = 7.26″; 2X = 5.445″; 3X = 4.84″; 4X = 4.5375″; 5X = 4.356″; and 6X = 4.235″. We immediately see from a consideration of these figures that no simple ratio exists between them as is the case with the easel distances; therefore, in order to effect automatic focusing it becomes necessary to design a suitable mechanism which will cause these distances to adjust themselves automatically. [In considering these two sets of figures it is interesting to point out the fact that if we multiply any negative distance by the degree of enlargement for that distance, the result will equal the easel distance for that particular degree of enlargement. For example: take a 5X magnification. Here the negative distance is 4.356″ and 5 x 4.356″ = 21.78″ which is also the easel distance for a 5X enlargement. This constitutes a reliable check when computing the easel and negative distances, or major and minor foci for different degrees of enlargement.]

The Rack and Pinion. We have seen from the foregoing that each added degree of magnification advances the lens one focal length further from the easel (assuming the easel to be stationary and the lens to move). A suitable rack and pinion for this work is a rack of brass ¼″ square and 24″ long (4) Fig. A of 48 pitch which meshes with the pinion wheel, (35) Figs. G and S, 1″ in diameter having 48 teeth with a ⅛″ or 3/16″ face. The rack and pinion are regular stock articles obtainable from any gear supply house. The rack is held in a groove cut in the top of one of the guide rails starting ½″ from the hinged line X–X′ and extending along the guide rail a distance equal to the length of the rack. See (4) Figs. A and S. The rack makes a tight fit in this groove and projects above the surface of the guide rail 3/32″. The rack must be parallel with the raised surface of the strips set into the main base otherwise the auxiliary base, which carries the pinion engaging with the rack, might move freely when the pinion is at one end of the rack and bind at the other end if there is a lack of parallelism.

Relation Between Easel Distance and Rack and Pinion Movement. The camera employed as the enlarging lens is held rigidly in the chair device resting on the auxiliary base. Now by racking in and out the auxiliary base the distance between the easel and the lens varies according to the movement imparted to the auxiliary base by the rack and pinion. This movement accomplishes half the problem of automatic focusing.

It is necessary at this point to determine how many turns of the pinion are required to move the lens one focal length, or the equivalent of one degree of enlargement, from the easel. The lens of the Ansco Speedex camera here described has an equivalent focus of 3.63″, which is the distance the auxiliary base must move from the easel for each degree of enlargement; for a lens of 2.874″ equivalent focus the auxiliary base should move 2.874″ for each degree of enlargement. To convert this distance into terms of revolutions of the pinion gear meshing with the rack, as the pinion is 1″ in diameter, one complete turn will move the auxiliary base a distance of 3.1416″, but it should move 3.63″; therefore, the pinion must make $1\frac{1}{6.43}$ revolutions. [It would be possible, of course, to employ a rack and pinion whose pitch and diameter were such that one turn of the pinion would advance the auxiliary base one focal length; but this would entail the construction of a special rack and pinion which would not be readily obtainable as a stock article and therefore much more costly than the combination here described.]

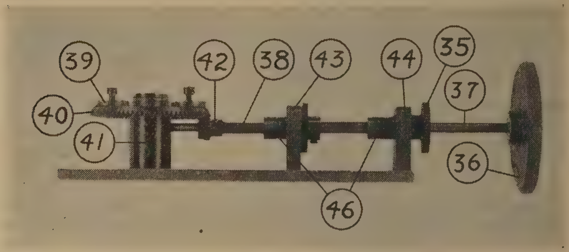

Fig. H

Relation Between Negative Distance and the Rack and Pinion Movement. The next step is to work out a scheme whereby the indirect ratio of the negative distances may be coordinated with the rack and pinion movement. Suppose the axle, which is attached to the auxiliary base and to which is fitted the pinion, is also provided with a gear train actuating a small bevel gear which engages with a large bevel gear rotating on a vertical spindle on the auxiliary base. See Fig. G. As the auxiliary base is racked in and out a rotary motion is imparted to the large bevel gear. If we fasten a cam shaped metal disc to the large bevel gear the cam will turn when the auxiliary base is racked in and out. If the edge of this cam presses against a stud on the negative holder, the negative holder will move with respect to the lens while the lens is moving with respect to the easel and by causing these movements to take place in the correct ratios the whole problem of automatic focusing will be solved.

The Cam Driving Mechanism. A sheet of brass or aluminum with the dimensions shown in Figs. F, H, I and S is set into the auxiliary base flush with the surface. A brass bearing block (44) is screwed even with the edge of the metal base. In the center of this bearing block a ¼″ hole is drilled. The height from the bottom of the block to the center of this hole is determined in the following way. The auxiliary base with the metal plate set in position is slid on the main base between the two guide rails. Then the 1″ pinion is placed in position on the rack opposite the bearing block. It will now be quite easy to locate and mark the center of the hole in the block to coincide with the center of the hole in the pinion. When this distance has been ascertained all the other bearing holes in the bearing blocks and the one in the vertical spindle or pillar are drilled at the same height above the surface of the metal plate. Another bearing block (43) is also screwed to the base plate in the position indicated by Figs. H, I and S. This block has two ¼″ holes drilled in it ¾″ apart. A piece of steel rod ¼″ in diameter (drill rod) 5″ long (37) rotates in these bearings. This rod or axle projects beyond the plate about 2⅜″ and a hand wheel (36) is

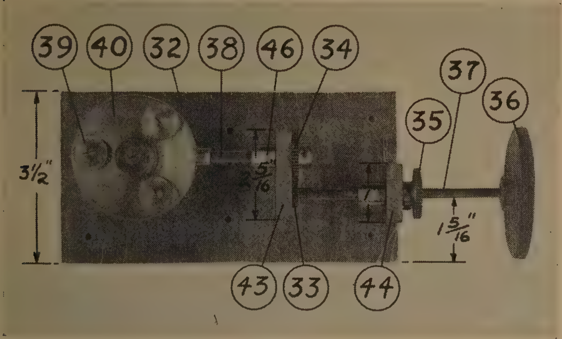

FIG. I

rigidly attached to the outer end. The 1″ pinion wheel (35) already referred to is now rigidly attached to the axles in such a position that when the auxiliary base is moved on the main base the pinion will engage with the rack. At the other end of the axle a ½″ diameter, 48 pitch gear wheel with ⅛″ face is attached (33). The vertical spindle (41) is now screwed to the plate in the position shown, and is prevented from turning by the pin indicated in Fig. S.

Another ¼″ axle (38) rotates in its bearing in block (43) and a hole drilled in the vertical spindle. The end of the axle supported by the pillar is turned down to 3/16″ in diameter to fit the hole in the small bevel gear (42) so the hole in the pillar must be 3/16″ instead of ¼″ as in the bearing blocks. On the outer end of this axle a 1″ diameter, 48 pitch, gear wheel with ⅛″ face (34) meshing with the ½″ wheel is attached. A shoulder is turned down on top of the pillar to fit the hole in the large bevel gear wheel (40). This wheel is 2½″ in diameter, 80 teeth and ¼″ face. (The journal or the shoulder on the vertical spindle and the bevel gear comprise the vertical spindle referred to in the discussion of the hypothetical apparatus.) The small bevel gear wheel (42) is ½″ in diameter, 16 teeth and ¼″ face and is attached to the axle (38) and its teeth mesh with those of the large bevel gear. When hand wheel (36) is turned the pinion, meshing with the rack attached to the main base, causes the auxiliary base to move. The small gear (33) on axle (37) is one-half the diameter of the large one on axle (38); consequently the latter rotates one-half as slowly as the former; and as the gear ratio between the small bevel gear and the large one is 1–5, the large bevel gear makes one complete revolution while the hand wheel is making ten complete turns. [Instead of using a pair of bevel gears and the pair of spur gears to bring about this gear reduction, a more practical plan would be to employ a worm and gear. In this case the axle carrying the 1″ pinion engaging with the rack would be extended and the worm wheel attached at the far end while the gear wheel meshing with the worm would be supported on the vertical spindle. This plan eliminates the pair of intermediate gears but entails the construction of a special worm and gear. The present arrangement was adopted because the gear train described can be purchased as stock articles from any gear supply house.]

The reason for slowing down the rotation of the large bevel gear to which is attached the cam is this. The apparatus has been designed to give a maximum enlargement of 8X. The rack and pinion movement is such that $1\frac{1}{6.43}$ revolutions of the pinion are necessary for each degree of enlargement; hence the maximum enlargement of 8X would require the pinion to revolve $8 \times 1\frac{1}{6.43}$ or a little less than ten revolutions of the hand wheel. Therefore, if we did not have a gear reduction between the pinion and the large bevel gear equal to or somewhat greater than one to nine, the large bevel gear would revolve more than one complete revolution while the hand wheel was turning through the necessary revolutions to produce the maximum enlargement of 8X. And if the large bevel gear, to which is attached the cam, should make more than one complete revolution, the cam would not function properly.

Cam Fundamentals. It is worth while to repeat that the whole problem of automatic focus enlarging is centered around a mechanical device which will automatically adjust the negative distance with respect to the lens while the lens is being moved with respect to the easel. The rack and pinion movement takes care of the distances separating the lens and the easel, and if the reader will just remember that attached to this rack and pinion mechanism and actuated by it is a train of gears which causes a cam shaped disc to revolve slowly with the edge of the disc pressing against and moving the negative carrier, he will find that auto focusing is really quite simple.

One or two simple analogies will afford the layman a complete understanding of the cam and its function. The rack and pinion supplies definite motion; i. e., if you turn the pinion a definite number of revolutions the auxiliary base will move a definite distance per turn of the pinion toward or away from the easel. It may be likened to a stairway wherein the width and height of each step is the same. As you mount the stairway you are raised a definite distance from the floor and also moved away from the foot of the stairway a definite distance by each step mounted. As both the tread and the rise of the steps are the same for each step you could stretch a string from the first step to the last one at the top and each step in between would touch the string. Suppose, however, that the tread or width of the steps remains the same but the first step raises you say 12″ from the floor; the second step 9″; the third step 7″; the fourth one 6″; the fifth one 5½″ and the last one 5¼″, you would find that a string stretched from the first step to the last would not touch any of the intermediate steps. To touch all the steps the string would have to assume a curved shape; the sharpest portion of the curve being at the lower part of the stairway, gradually flattening out as it neared the top. The varying heights of these steps may be likened to the distances of the negative from the lens for different degrees of enlargements. Referring to page 416 giving the negative distances for six different degrees of magnification, it will be noted that the greatest distance is one degree; 2X is considerably shorter; 3X somewhat shorter; and as the 6th degree of magnification is approached the distances become more nearly the same. If we were to erect seven parallel lines from one base line, the distance separating each pair equalling the focal length of our lens (which would be comparable to making the width of each step the same in the case of the stairway) and make the length of the first line equal to the negative distance for 1X, the length of the second line equal to 2X, and so on to the last line, we would find that in order to connect the tops of these perpendicular lines we would have to draw a curved line as we found it necessary to curve our string on the stairway.

Instead of erecting these lines on a common base, we might have them radiating from the center of a circle like the spokes of a wheel, with the angle between each pair the same. Starting from any one line we might lay off the distance from the center of the circle equal to the negative distance for 1X; the second line equal to 2X;

the third 3X; and so on, and to connect the ends of these spokes or radii, we would have to draw an irregular curve.

By modifying the above procedure slightly and drawing the curve on the rotating disc attached to the large bevel gear mounted on the vertical spindle of our hypothetical apparatus, and then cutting the contour of the disc to conform to the irregular curve, the disc will move the negative holder a large or small distance according to the varying periphery of the cam, while the lens is moving with respect to the easel; and this disc with its irregular curved periphery is the cam of the automatic focusing apparatus.

Construction of the Cam. The reader's attention is now directed to Fig. T which is a full-sized drawing of a cam suitable for the two most popular miniature cameras, those with lenses approximating 3″ in focal length, and those of approximately 3½″. Looking at the illustration with the legend Fig. T at the bottom of the drawing, the illustration is in the correct position for considering the development of the 3½″ cam which is indicated by heavy lines. Turning the page clockwise through 90 degrees, or until the legend, Fig. T, is at the left, the illustration is correctly positioned for the development of the 3″ cam, which is indicated in light lines. Only the outline of the 3½″ cam is drawn heavy, however, the radii of both cams being drawn alike. The 3½″ cam will be dealt with here, but for those who plan to build an apparatus for 3″ lenses, it is only necessary to state that exactly the same procedure is to be followed, substituting the 3″ drawing for the 3½″ one, likewise the other data supplied. (For those who desire to follow through the actual theory and design of the cam, the complete development including the necessary formulae, calculations and tables are given later under the subtitle *Cam Design.*)

Sheet brass 1/16″ thick is an excellent material with which to make the cam, although sheet aluminum could also be used. The first step is to trace the drawing of the cam on the metal plate. The drawing is attached to the sheet of brass by several dabs of paste or glue (Grippit is good for this purpose). The whole sheet should not be covered with the adhesive as this might distort the drawing thus destroying its accuracy. When the drawing has been attached mark the center O Fig. T of the cam by a prick mark. A mechanic's scriber, stout needle, or any sharp metal point will do this accurately. Next prick mark the points along the outline of the cam including the three holes (45) Figs. G and T, by which the plate is fastened to the large bevel gear. After all the points have been marked the drawing may be removed from the plate. The contour curve of the cam should now be drawn through the points on the metal plate; also the major radii; i. e., OE, 2.0, 3.0, . . . 8.0.

If the foregoing instructions are carried out accurately an exact duplicate of the cam drawing, excepting the minor radii, should appear on the plate.

A Word of Caution. The reader has probably realized by now that the cam is the heart of the apparatus and the one part requiring the greatest care in its construction. Manifestly then any inaccuracy in exact dimensions of the cam will be serious. While making the transfer it is well to check the work occasionally by measuring some of the radii drawn on the metal plate and comparing the results with the distances given in the table for the cam under construction. This is advisable because the engraving of the drawing may vary slightly from the original, or some slight error might be made in the transfer. All measurements are to be made from the outside edge of the circumference of the base circle, first subtracting 2 from each radius length, because the distance from the center of the base circle is 2″, and more accurate measurements are possible when working from the edge of the base circle outline.

If the dimensions of the various parts of the drawing on the metal plate check with those of the figure in the monograph and with the dimensions given in the table, or with the dimensions computed for the particular lens used, the cam is ready to be cut out to shape. It should be cut out roughly, first, care being taken not to run inside the line of the curve. After this has been done the final grinding or filing down to the line of the curve is made. This part of the work must be done very accurately, filing or grinding as close as possible to the line.

A ¾″ hole is next made very carefully at the center of the cam for the purpose of centering the disc on the vertical spindle.

Another and Better Way to lay out the cam is this. Having roughly located the center of the cam on the sheet of metal, the ¾″ hole is drilled. Now turn down a shoulder, the height of which is about the thickness of the metal plate, on a piece of brass rod which will fit the ¾″ hole snugly. Before the piece of metal rod is removed from the lathe a very small center hole is made. The sheet of metal is now placed on the brass stud and the engraving of the cam placed on it so the center of the latter exactly coincides with the center hole in the stud projecting through the ¾″ hole in the plate. The balance of the work of transferring the drawing to the plate is then carried on as already described. By drilling the hole first all danger of drilling it off center after the outline of the cam has been transferred to the sheet of metal is avoided.

The three elongated holes (45) Fig. T are then drilled in the plate. It will be apparent from Figs. F and G that the cam fits on a shoulder turned down on the vertical spindle and rests on top of the large bevel gear to which it is attached by three screws passing through the elongated holes already mentioned.

The apparatus as far as we have considered it now consists of the enlarging back, the main base and an auxiliary base which slides back and forth on the main base by means of a rack and pinion movement which in turn actuates a train of gears causing the cam to revolve slowly on the vertical spindle. The parts of the apparatus carried by the auxiliary base will be described next.

The Camera Bracket, which carries the camera whose lens is used for the enlarging lens, resembles somewhat a chair without a back (15) Fig. L. The camera (16) Fig. B, with its back removed and platform opened and bellows extended, fits into this chair device with the platform resting on the bottom of the bracket. The front of the lens faces the enlarging back. No working dimensions are given for this part of the apparatus as its shape and dimensions will have to be modified to hold different types of cameras, but the distance between the surface of the main base and the optical axis of the enlarging lens is determined as follows: The center of the plate holder is first found by drawing diagonals on the slide. The distance is then measured from the intersection of these diagonals to the surface of the main base after the holder has been inserted in the enlarging back and this distance will be the correct distance between the main base and the optical axis of the enlarging lens.

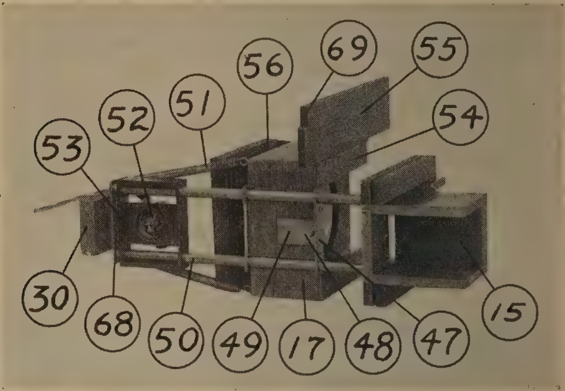

Fig. J

The bracket is mounted at the left end and in the center of the auxiliary base by screws which pass up through the auxiliary base into the bracket.

The Condenser Housing, Fig. S, is a box constructed of ½″ poplar wood; its principal dimensions are indicated in Fig. S where a front and side elevation of the condenser housing is shown. The pair of plano-convex lenses comprising the condenser are 4½″ in diameter and have an equivalent focus of 2½″. Holes 4″ in diameter are cut in the center of the front and back faces of the box with circular rebates (78) Fig. S, ⅜″ deep and ¼″ wide into which fit the condensers, these being held in position by the spring wire rings (79) which snap into place after the condenser elements have been inserted in the grooves. When the parts of this housing are being constructed provision may be made for the insertion of a sheet of ground glass in a groove (76) between the two condensing lenses; although a better plan is to have the ground glass between the light source and the condensers as (62) Fig. K. .

Two strips of wood (54) Figs. J and S are screwed to either edge of the back face of the housing next to the camera bracket. These wooden pieces form a slide into which fits the negative holder (82) Fig. S, and this is held in place against the face of the housing by means of flat bowed springs (77) set in either strip. As will be seen from Fig. S, the top of the condenser housing is built with a hinged section (20) swinging up in the direction of the arrow when the negative holder is inserted or withdrawn.

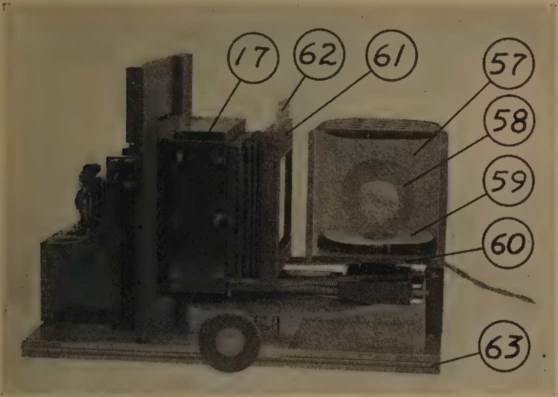

Fig. K

The Negative Holder, Fig. P, is quite simple to construct. It consists of a 4 x 5 printing frame which has been cut down to ⅜″ in thickness. The ordinary hinged back is replaced by two U shaped metal sections (73), Fig. P, ⅛″ thick, hinged to the frame. The rectangle inclosed by the opening formed when the two metal sections are closed measures 2½″ x 3½″, or ⅛″ greater each way than the maximum size of the negative to be enlarged. See Fig. R which shows the hinged pieces flat.

Two swiveling bowed springs with notches (74) Fig. P are attached to one of the hinged sections. The notches engage under the heads of two protruding screws in the other piece. A sheet of clear glass 4 x 5 inches is placed in the printing frame, the negative is placed on this sheet of glass, emulsion side up, and a paper mask is put over the negative. The hinged members are then pressed down and the springs caught under the screw heads. These springs exert sufficient pressure to hold the negative in flat register with the glass and the entire construction is such that no glass is between the negative and the lens, thus avoiding any distortion that might arise if glass came between the negative and the lens.

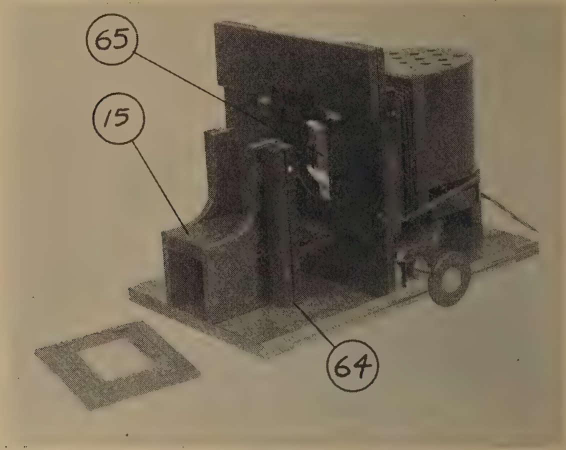

FIG. L

When the printing frame or negative carrier is inserted in the grooves formed by the two wooden pieces attached to the back side of the condenser housing, the center of the frame will be on the optical axis of the apparatus with the negative, emulsion side towards the lens, about ⅜″ from the surface of the rear condenser element. If the apparatus is to be used with both plate and film negatives, strips of cardboard the thickness of the glass negatives must be inserted between the printing frame and the condenser housing, when using film negatives, to compensate for the difference in thickness between them. This must be done to insure both emulsion surfaces registering in the same plane. The negative masks (75) Fig. P are made of thin bristol board and fit the frame snugly; i. e., without any appreciable movement. Several of these masks should be made up containing different sized openings. Thus any portion of a negative may be masked by shifting the negative under the mask before the springs are pressed down, and the construction of the holder insures the masked portions of the negatives being correctly centered on the optical axis of the apparatus. As the

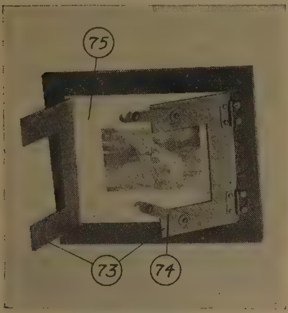

Fig. P

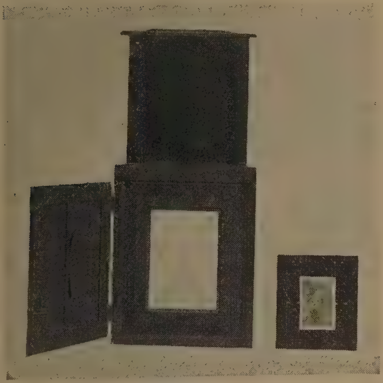

Fig. R

greatest dimension of the negative is but 3¼″ and the smallest of the printing frame 4″ and the clear surface of the condenser 4″ in diameter, the negative may be turned in any position to mask properly such portions to be enlarged.

The Bridge Over the Cam Mechanism. The negative must be free to move back and forth with respect to the enlarging lens while the latter moves with respect to the easel. This is accomplished by a bridge over the cam mechanism. Two brass rods (50) Figs. J and S, ½″ in diameter and 14¼″ long are attached to the camera bracket at one end of the auxiliary base and to a block of wood (30) at the other end. These rods are 3⅛″ between centers. Holes are drilled and tapped in the ends of the bridge members to receive machine screws. Two brass plates with holes in them 3⅛″ apart and fitting the screws just mentioned are then screwed to the ends of the rods. These brass plates (68) Figs. J and M are attached to the camera bracket and the wooden block by screws.

Two similar brass plates (47) with ½″ holes 3⅛″ between centers are next fastened to either bottom edge of the condenser housing. Two grooves (81) Fig. S, ⅝″ wide and ⅜″ deep are cut in the bottom of the housing at the proper point to afford clearance for the bridge rods.

If the work has been done correctly it will now be found that when the block and the camera bracket to which are attached the ends of the bridge members, are placed on the auxiliary base, the condenser housing will slide freely on the rods, clearing the cam mechanism beneath. As will be apparent from the illustrations, the distance from the optical axis of the condensing system to the main base is the same as the distance of the axis of the enlarging lens and the intersection of the diagonals of the plate holder in the enlarging back to the main base; and the metal plates supporting the condenser housing and which slide on the bridge rods do not touch any part of the cam mechanism below.

The Cam Stud. Before the bridge is attached permanently to the auxiliary base the stud, against which the cam presses, should be attached to the bottom of the condenser housing. The stud, (48) shown in cross-section in the side view of the condenser housing in Fig. S, is a steel roller in the form of a tube about ½″ in diameter and ½″ long (48). It makes a nice rotating fit on the shank of the steel screw which screws into the brass plate (49) Figs. J and S. The edge of the cam (28) Fig. S rolls on this roller, the roller revolves on the screw, thus reducing friction to a minimum.

The Illuminator or Lamp House (57) Figs. C and K is constructed of metal. Its base (60) Fig. K is a piece of aluminum ¼″ thick and 5½″ long. The sides are square with the front for a distance of 2¾″ then follow the arc of a circle whose radius is 2¾″. The lamp socket is a metal display sign socket and is fitted tightly into a metal sleeve (66) Fig. M. (52) Fig. J shows the bottom of the socket where the wires are attached. This sleeve makes a sliding fit in a metal tube (67) Fig. M which is attached to a metal plate or stage (53) Fig. J. A set screw lacks the socket and its containing sleeve at any height. The stage moves laterally with respect to the bridge rails by sliding in grooves cut in two metal plates which in turn slide on the bridge rails. This construction affords a vertical movement, a lateral movement and a back and forth movement of the lamp socket on the bridge rails; thus the electric lamp may be raised or lowered until the filament (center of illumination) is on the optical axis of the apparatus, and the lamp stage may be adjusted with reference to the condensing system so the cone of light emerging from the condensers comes to a focus on the enlarging lens.

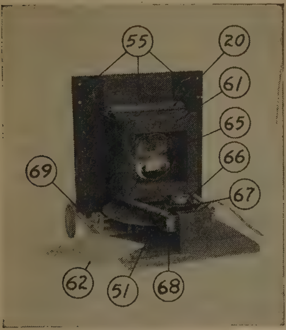

Fig. M

The lamp house proper is made of sheet tin or preferably of polished nickel plated sheet brass because it has been found by experience that it is difficult to get a suitable white enamel for the inside of the house which will withstand the intense heat given off by the lamp. Nickel plated brass or polished aluminum will afford nearly as much reflection and diffusion of the light rays as a white enameled surface and will not be affected by the heat. The walls of the house are about 6″ high which brings it nearly to the same level as the top of the condenser housing. It is fastened by screws to the base plate. A top of metal and similar in shape to the bottom is riveted to the walls. Both the top and the bottom are pierced by ½″ holes to afford ventilation; and to prevent light passing through these holes, two baffle plates 5″ in diameter (59) Fig. K are placed inside the housing but separated from the top and bottom a distance of ½″ by metal pillars. The base is pierced at the center of the arc of the circular end by a hole threaded to screw on top of the sleeve (66) Fig. M moving vertically in the tube (67) Fig. M attached to the stage sliding on the bridge members. The lamp (58) Fig. K is a 250-watt stereopticon bulb. The lower baffle plate is provided with a hole 1⅝″ in diameter through which the bulb passes when it is screwed into its socket.

Fig. K shows the lamp house partly unscrewed from its support so the inside construction is apparent. The side walls of the house are made about ⅜″ longer than the base plate and these are bent at right-angles and drilled with three holes. The distance of the light source from the condenser varies with different degrees of enlargement, and to prevent light leaking out between the condenser housing and the lamp house, a simple bellows of square form (56) Fig. C closes the opening. The making of such a bellows was described in The Photo-Miniature: No. 123. One end of this bellows is fastened to the condenser housing and the other terminates in a wooden frame (61) Figs. K and M which is attached to the lamp house by means of the bent portions of the side walls of the lamp house already described. This frame is provided with a groove which holds a sheet of ground glass (62) Figs. K and M. It was pointed out on page 427 that instead of placing a sheet of ground glass between the condenser elements a more preferable method would be to insert the ground glass between the condensing system and the light source. Fig. M shows the lamp house removed from its support and the ground glass withdrawn from the groove in the wooden frame.

Condensers vs. Diffusers. The apparatus as described employs a condensing system because this type of illumination affords very rapid exposures when using chloride papers. Exposures of from 15–20 seconds from average negatives are possible using the condensing system. The construction of the apparatus could be greatly simplified, however, by eliminating the condensing system. In this case it would be necessary to place several sheets of ground glass between the lamp and the negative, necessitating longer exposures. The substitution of greatly diffused illumination does away with the construction of a condenser housing and the bellows; it also enables one to employ such illuminators as the Craig or Parallax apparatus obtainable commercially.

Some Minor Details. We will now consider the assembly of the apparatus. The auxiliary base with its fitments is slid onto the main base between the guide rails. The pinion engages with the rack and by turning the hand wheel the auxiliary base moves back and forth on the main base. It is necessary to devise a means for attaching the free ends of the window shade bellows to the auxiliary base. Fig. M shows the method adopted for doing this. The wooden strips (55) Figs. B, M and S, with the dimensions indicated in Fig. S, are attached to the condenser box. These strips do not quite touch the surface of the auxiliary base and a notch as indicated at (69) Figs. Q and S is cut in each one as clearance where they extend over the guide rails of the main base. The two strips attached to the sides of the condenser box and the cross strips joining them at the top and bottom, Fig. S, move integral with the condenser box and negative carrier. It is necessary, therefore, that the bottom edges of the strips do not touch the surface of the auxiliary base as already stated. This space need not be more than 1/16″ or 1/8″ and a strip of felt, indicated by the heavy black line in Fig. S, glued to the lower edges of the side pieces and the bottom cross piece, and sliding on the surface of the auxiliary base, will effectively block out any light leaking in at this point. The total height and width of this frame is of about the dimensions of the opening inclosed by the three window shades and base forming the bellows; so that the sides and top of the frame actually contact with the side and top bellows members; and as the bottom of the frame is rendered light-tight by means of the felt, very little, if any light leaks in. The free ends of the window shades are attached to the frame (55) by thumb tacks.

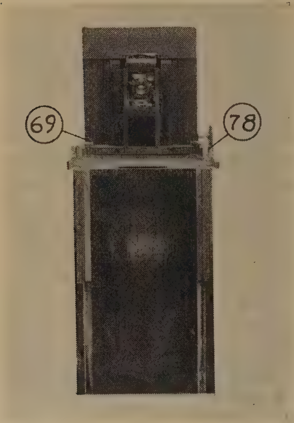

Fig. Q

Any stray light leaking in at the condenser housing end of the bellows is prevented getting to the bromide paper in the enlarging back by a baffle plate (64) Fig. N inserted in slots formed by wooden pieces screwed to either side of the camera bracket (15) Fig. L. The dimensions of the baffle plate are the same as those of the rectangular frame (55) just described, and the lower edge does not come quite to the surface of the auxiliary base; and the two bottom corners are cut away like the frame (55) Fig. M, to form clearance for the guide rails. Fig. N shows the baffle plate, which is made of cardboard painted dull black, in place, and Fig. L shows it removed.

When the auxiliary base is racked away from the enlarging back the cam moves the negative towards the lens and so long as this movement is continued the cam presses against the stud under the condenser housing. If the auxiliary base is racked towards the enlarging back, however, the stud does not follow the cam. It is necessary therefore to provide a pair of coiled springs (51) Figs. J and M which pull the condenser housing against the cam at all times. These springs must be strong enough not only to keep the stud pulled against the cam but to overcome the opposite pull of the springs in the window shade rollers.

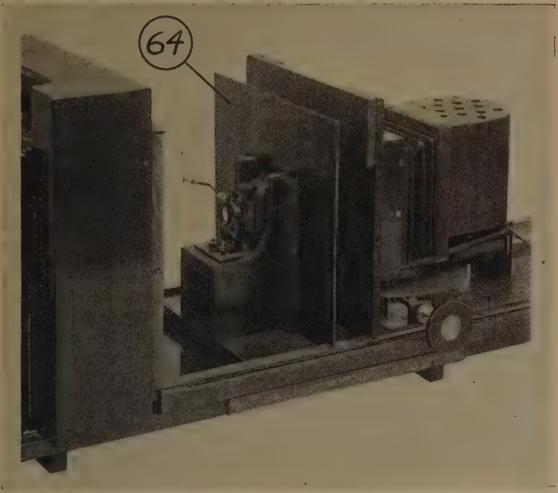

FIG. N

Heavy rubber bands would do as well as wire springs but they suffer rapid deterioration

Assembly and Adjustment. We are now ready for the final assembly and adjustment of the apparatus. The auxiliary base is started between the guide rails at the right-hand end and pushed along the main base until the pinion engages with the rack. The hand wheel is then turned, rotating the cam, as the auxiliary base is racked towards the other end, and by the time the auxiliary base has reached a position on the main base approximating one degree of enlargement, the cam may have turned around to a point corresponding to about an 8X enlargement. To avoid this it is necessary to rotate the cam around to a point on the periphery at the end of the 8X radius before the auxiliary base is started toward the other end of the main base. When the pinion then engages with the rack the cam will unwind, so to speak, as the auxiliary base is racked towards the easel end. After the position of about 1X enlargement has been reached it will be found that the cam has also reached a point where it touches the stud corresponding to a 1X enlargement.

Having racked the auxiliary base down towards the enlarging back, with an approximately correct setting of the cam, the next step is to make the adjustment for say a 3X enlargement between the focusing screen, the enlarging lens and the negative. The distance from the nodal point of emergence to the focal plane of the lens, or in this case, to the emulsion side of the negative which should face the enlarging lens is 4.84″ (negative distance for a 3X enlargement), for a lens having an equiv. focus of 3.63″. With a lens of any other equiv. focal length the factor 3.63″ should be replaced by the equiv. focus of the lens used.

If the nodal point of emergence of the lens is not known it must be determined by trial. In the case of a symmetrical lens, however, the nodal point is usually at the center of the iris diaphragm or the back surface of the diaphragm. With a lens of the unsymmetrical type we proceed as follows. After the reference mark is made on the platform or bed of the camera indicating the distance the lens should be from the emulsion surface of the negative (4.84″ for the case under consideration) for a 3X magnification when the point on the periphery of the cam at the end of the 3X radius is in contact with the stud roller, the camera is adjusted on the bracket until this mark is exactly 4.84″ from the negative. The lens mount or support is now moved so the approximate center of the lens coincides with the mark. The ground glass focusing screen is then placed in the enlarging back and by means of the critical focus adjusting screw (71) Fig. C the focusing side of the glass is moved to a point 14.52″ from the reference mark on the camera (14.52″ being the easel distance for a 3X magnification or enlargement).

When the above adjustments have been made we have the following conditions. The point on the periphery of the cam at the end of the 3X radius is touching the roller on the negative carrier; the distance from the emulsion surface of the negative to the reference mark on the bed of the camera is 4.84″; and the focusing screen has been set at the proper distance from the reference mark for a 3X magnification; the lens also occupies an approximately correct position. To set the lens precisely the negative is illuminated and the lens (*not the camera*) is moved back or forth on the camera bed until the image on the ground glass screen is sharp. A good way to do this is to draw a line say 2″ in length on a negative and then adjust the lens until the image of the line is 6″ in length. When these adjustments have been made, the lens occupies the correct position for enlarging and by measuring forward 3.63″ from the focal plane of the camera to the lens the nodal point of emergence of the lens is determined.

When the above adjustments are completed the exact position occupied by the lens should be marked on the camera so when it is removed the camera and lens may be replaced at the right point for automatic focusing. Should the camera not be of the platform type, but one where the front is extended and held rigidly in place, focusing being accomplished by moving the lens in the lens mount, note should be taken of the position occupied by the lens when it is in final adjustment so it may be returned to this point each time the camera is used as an enlarging lens. It is obvious, of course, that the camera itself should occupy the same place on the camera bracket every time it is put in position for enlarging.

The apparatus is now in final adjustment and any racking in or out of the auxiliary base will cause the image of the negative on the focusing screen to grow or shrink in size, remaining critically sharp the while.

The cardboard baffle plate is next placed in position and the side curtains forming the bellows attached to the frame on the condenser housing.

Adjustment of the Illuminant. The lamp should now be adjusted. Remove the negative holder and adjust the lamp back and forth on the bridge rods until a bright circle of light, as free as possible from color, is projected onto the ground glass. If the light is too bright near the top of the circle the illuminant should be raised slightly until the circle of light is of even brightness throughout its area. When an evenly illuminated circle of light has been obtained, correctly centered, replace the negative and holder and rack the auxiliary base out to say a 4X magnification of some part of the negative. Now remove the negative holder again and examine the circle of light. If it is bright and even all over it is correctly adjusted. If too bright in the center, the light is too far away from the condenser and should be brought forward until the disc of light is evenly illuminated. If, on the other hand, the center of the disc is dark, the light is too near the condensers, and must be pushed further away. These adjustments should be made without the ground glass inserted between the condenser and the illuminant. When they have been made the ground glass may be replaced.

Condensers like other lenses possess conjugate foci and for this reason it is necessary to adjust the position of the illuminant with respect to the condenser system as the degree of enlargement changes in order to have the apex of the cone of light formed by the condensers will always focus on the enlarging lens. For small changes in magnification of the projected image the position of the illuminant as found above need not be altered, but if a great change is required in the size of the projected image, for instance from 2X to a 6X enlargement, the illuminant should be adjusted until the circle of light is even. In fact it is a good plan to mark on the bridge rods, points where the illuminant should be placed for the major degrees of enlargement. When enlarging it is only necessary then to slide the lamp housing on the rods to the point which corresponds approximately with the degree of magnification being used. It is also desirable to indicate along the guide rail holding the rack the major divisions of magnification.

Size of Enlargements. It is to be understood, of course, that it is not possible to amplify a 2¼x3¼ negative to a full 8X enlargement when using the apparatus as a self-contained unit, because the sensitized material holder will only accommodate an 8 x 10 sheet of enlarging material which is somewhat smaller than a 4X enlargement. When it is desired to enlarge such negatives to a full 8X size the apparatus must be used with independent easel. It is possible, however, *to enlarge portions* of these negatives to 8X with the apparatus in the self-contained form; and enlarging small areas of negatives will constitute a considerable part of the work done with the amplifier.

The Apparatus as an Automatic Projection Printer. So far we have considered the apparatus in the form of a self-contained enlarging camera producing a maximum enlargement of 8 x 10. As was stated earlier the apparatus is made to serve a dual role. Fig. A shows the main base as a continuous unit hinged on the line X-X. The brass strips (18) Fig. B screwed to the edges of the main base hold it in the flat form. In Fig. D the screws holding that portion of the brass strips attached to the shorter section of the main base have been removed and this section swung down. Before the short section is dropped, the enlarging back must be removed from the main base by unscrewing the upright stud (19) Fig. C, holding the threaded axle of the critical focusing device, from the end of the main base and lifting the enlarging back with its window shade rollers, etc., from the grooves in the main base; the free ends of the shades having been detached, of course, from the frame fastened to the condenser housing on the auxiliary base.

The horizontal section, Fig. D, rests on a table or other support. The point at which the main base is hinged and the projecting ends of the brass strips must be so determined, that lines drawn from the enlarging lens to the outer limits of the 8X enlargement are not intersected by these projecting strips. Fig. Q shows an end view of the apparatus with short section dropped down.

It is necessary, when using the apparatus in this form, for enlargements greater than 8 x 10, to work in a darkened room. The apparatus rests on a table and the easel is suspended on a wall or otherwise supported at the proper distance from the table on which rests the horizontal section of the main base and the balance of the apparatus. This distance is determined as follows: The auxiliary base is racked out to any convenient point, say where it will give a 4X enlargement. The easel is then adjusted until the image is critically sharp. This is the correct position for the easel, because any further racking in or out of the auxiliary base will only increase or decrease the size of the image without altering the focus; i. e., we now have the same conditions to work under as though we were using the outfit as a self-contained unit except that we have substituted an easel for the enlarging back.

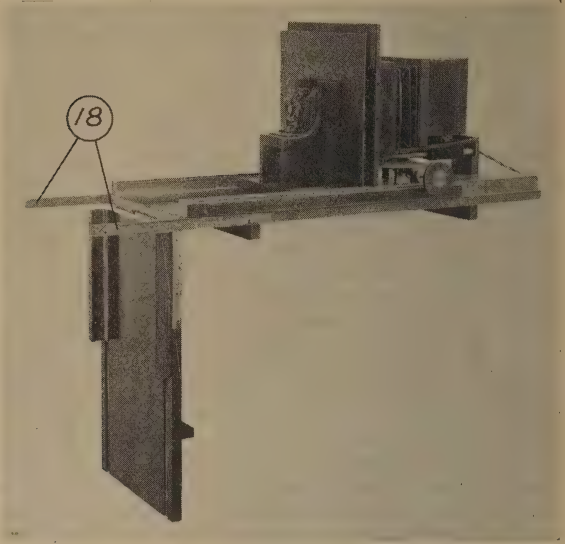

Fig. D

It is perhaps well to remark at this point that when the outfit is in the self-contained form it is not possible to make corrections for distorted images, especially of negatives showing distortion of the vertical lines, as in architectural subjects, etc. The only adjustment possible and desirable from many standpoints is the one of centering such portions of the negatives to be amplified on the optical axis of the apparatus; neither does the negative holder turn in a plane parallel to the easel. This adjustment is taken care of when the negative is masked and placed in the printing frame holder. This holder is large enough to allow the negatives from miniature cameras being turned in any position parallel to the bromide paper holder.

Advantages. In the apparatus under discussion the sensitized paper holder, the lens system, the negative, and the illuminant are unalterably centered correctly with respect to the optical axis of the device, insuring perfect illumination at all times; a much more desirable and necessary feature than some of the many elaborate adjustments found in other types of enlargers and which are seldom required. When they are needed the apparatus used with independent easel, which may be tilted or otherwise adjusted, will take care of them satisfactorily. In other words the device is as near fool and trouble proof as it is possible to make one. It will be found that out of all negatives about 90% of them will be just plain straight enlargements between 5 x 7 and 8 x 10. With the remaining 10% it may be desirable to enlarge greater than 8 x 10 or they may require corrections, dodging, vignetting, etc. When any of these operations are necessary, the apparatus must be used as any other type of automatic enlarger—in a dark room. It may be well to remark too that soft focus effects can be obtained with the apparatus in either form if lens "spectacles" or supplementary lenses are used in conjunction with the lens belonging to the camera, providing they do not alter the focal length of the lens. Or bolting silk may be used by the method outlined on page 410.

Fig. C shows the apparatus as a complete unit in the self-contained form ready for use. When it is desired to place the camera in its support or remove it, the free end of the top curtain of the bellows is detached from the auxiliary base and allowed to roll up to the other end, care being taken that it does not slip through the groove. The baffle plate of cardboard is then withdrawn and the camera taken out or inserted in its support; the baffle plate returned to its place and the curtain attached.

The Material and Parts needed for the construction of the foregoing automatic negative enlarger may readily be secured in most large towns, as follows: Lumber, well seasoned poplar wood and hardwood strips, from any lumber merchant or mill. The gears, toothed rack and similar metal parts from dealers in machine parts and supplies; condensers from photographic supply dealers or lens makers. The bromide paper holder suggested is that listed by the Eastman Kodak Company; window shades are obtainable from dry goods and upholstery stores. The illuminant is a 250-watt concentrated filament electric lamp sold by dealers in electrical supplies. It is estimated that the enlarger, home-made, should not cost more than fifteen or twenty dollars (less abroad) including the above mentioned items.

Automatic Enlargement of Large Negatives. The design and construction of the automatic enlarging apparatus described in these pages has been confined to a device for enlarging negatives produced with lenses of 3½″ focal length or less because of two reasons: (1) Our subject has been enlarging and the miniature camera and lenses of these small cameras rarely exceed 3½″ focal length; (2) The lens producing the small negatives is usually a high grade anastigmat covering completely the focal plane of the camera on which it is employed. Some readers may desire to design and build an automatic enlarger similar in principle to the one described but capable of making enlargements from negatives as large as 5 x 7″. For those who are interested in a larger automatic focusing apparatus let us see what modifications of the miniature camera apparatus are necessary in order to adapt it to large negatives.

The Lens. The focal length of the enlarging lens should be determined by the size of the negative to be enlarged and a safe plan is to have the focal length of the enlarging lens at least the equivalent of the diagonal of the negative to be enlarged. For instance, a 3½″ lens is about right for negatives 2¼″ x 3¼″, although 4″ would be better; a 4 x 5″ negative should have a 6 or

7″ lens; and for a 5 x 7″ negative a 9 or 10″ lens should be employed.

We have seen that for each degree of enlargement the rack and pinion movement must advance the lens a distance of one focal length. In the case of the miniature camera lens described in the text, this amounted to 3.63″ per degree of enlargement and for a 3″ lens, 2.874″ when the equiv. foci of these lenses are 3.63″ and 2.874″ respectively. Suppose, however, we desire to employ a 6″ lens for enlarging say 4 x 5″ negatives. Here the rack and pinion movement must be of such proportions that it will advance the lens 6″ per degree of enlargement if the equiv. focus of the lens is 6″; and a 9″ lens used with 5 x 7″ negatives would advance the lens 9″ per degree of enlargement. Obviously from these considerations it is apparent that the length of the main base of the apparatus as well as the rack and pinion movement will have to be modified to meet the new conditions. The length of the main base and the other components of the apparatus are easily altered, but a modification of the cam which regulates the negative distance is not so simple. We found that a cam developed on a 4″ circle was practically ideal for the miniature camera machine. Its largest dimension was less than the width of the main base, and although it might have been developed on a smaller base circle, for practical construction the size determined upon was satisfactory. If we employ a cam construction similar to the 3 or 3½″ cams, already described, for use with a 6 or 9″ lens it will be necessary to build these cams on a much larger scale.

By a comparison of the distances given in the table which follows, we will see that for each degree of enlargement, using a 3″ lens, the lens is advanced 3″ per degree of enlargement; a 6″ lens advances 6″ per degree of enlargement or twice the distance of the 3″ lens; and a 9″ lens three times the distance required for a 3″ lens. In the case of the negative distances we find for a 3X enlargement, using a 3″ lens, the negative distance is 4″; for a 6″ lens the negative distance is 8″ or twice that of the 3″ lens; and for a 9″ lens it is 12″ or three times that of the 3″ lens. Considering any other degree of enlargement and applying the same comparison, we find the same ratio exists; namely, the ratio between the enlarging distances for any two lenses is the same as the ratio between the focal lengths of the two lenses, as noted above.

Let us consider the enlarging distances given below for a 3, 6 and 9″ lens, taken from the tables that are published in most any book on enlarging.

DISTANCES WHEN ENLARGING

Focus of Lens, Ins.	TIMES OF ENLARGEMENT							
	1 Ins.	2 Ins.	3 Ins.	4 Ins.	5 Ins.	6 Ins.	7 Ins.	8 Ins.
3	6	9	12	15	18	21	24	27 easel distance
	6	4½	4	3¾	3 3/5	3½	3 3/7	3⅜ negative distance
6	12	18	24	30	36	42	48	54 easel distance
	12	9	8	7½	7 1/5	7	6 6/7	6¾ negative distance
9	18	27	36	45	54	63	72	81 easel distance
	18	13½	12	11¼	10 4/5	10½	10 2/7	10⅛ negative distance

The above values are only relative and are not to be interpreted as actual distances based on the equiv. foci of the lenses considered, unless the lenses listed actually have 3, 6 and 9″ equiv. foci respectively.

The Cam. If we apply a cam construction for a 6 or 9″ lens based on the design for a 3″ lens it is apparent from the foregoing that the dimensions of the cam will need to be altered according to the ratio existing between the 3″ and the 6 or 9″ lenses; and this would involve the building of a cam much too large for practical construction. As an example, suppose we are using a 9″ lens and desire to make a cam producing a maximum enlargement of 6X from a 5 x 7″ negative. If 9″ represents the equiv. focus of the lens, the negative distance for a 6X enlargement would be 10½″ and without even concerning ourselves with the diameter of the base circle on which the 9″ cam would be constructed, we find the cam would be over 20″ in diameter, which, although of possible construction, is impracticable. The best plan to follow in dealing with cams for the making of enlargements from 5 x 7 negatives is to employ the 3″ or 3½″ cam described and work out a device whereby the movement imparted to the negative carrier by the small cam may be stepped up to meet the conditions demanded of the longer focus lens. This stepping up device could be made of a lever arrangement or a rack and pinion movement *interposed* between the small cam and the negative carrier. The ratio of this stepping up device must be exactly that existing between the short lens and the long lens; i. e., if the relative focal lengths of the two lenses are 3 and 9″ and the ratio between their equiv. focal lengths is 1–3, then the stepping up ratio must be 1–3. Or to state it another way, the movement of the 3″ cam must be magnified before it reaches the negative carrier an amount equal to the ratio existing between the 3″ lens and the lens to be employed with the large negatives.

It is not within the province of this monograph to give working instructions for building an enlarger for use with large negatives, but the reader can get the fundamentals for the design of such an apparatus from the information just given. Not only would it be necessary to alter the dimensions of the main base but also to alter the size of the negative carrier, the lamp housing, etc. The construction of a large apparatus would also be confined in all probability to a projection printer with independent easel. In this connection it is also to be noted that when the rack and pinion mechanism is altered to meet the conditions required by a longer focal length lens, the cam driving mechanism must also be changed accordingly.

Cam Design. Where a cam must be designed and developed to fit a particular lens, the following method is advised. The rack and pinion movement automatically adjusts the distance between the easel and the lens. The distance separating the negative and the lens must be altered simultaneously with the changes in the easel distance. This is accomplished by the train of gears actuated by the rack and pinion mechanism. The gear reduction is such that the movement of the large bevel gear, to which is attached the cam plate, is $^1/_{10}$th of the movement of the small pinion engaging with the rack. In other words if the small pinion moves through a complete revolution or 360° of arc, the large bevel gear wheel moves through 360°/10, or 36°.

Let a be the length of arc through which the small pinion turns; r the radius of the pinion; and $180/\pi$ the factor converting arc into degrees; then A_1, the angle through which the small pinion turns, is

$$A_1 = \frac{a}{r} \times \frac{180}{\pi} \qquad (1)$$

For the large bevel gear, the angle is

$$A_2 = \frac{a}{r} \times \frac{180}{\pi} \times \frac{1}{10} \qquad (2)$$

Taking the case described in the text where the 3½″ lens has an equiv. focus of 3.63″ and the radius r equals ½″ and substituting in equation (2)

$$A_2 = \frac{3.63''}{0.5''} \times \frac{180}{\pi} \times \frac{1}{10} = 41.597^\circ$$

41.597° is the number of degrees the large bevel gear wheel turns through while the pinion is turning through $1\frac{1}{6.43}$ revolutions or the distance necessary to advance the lens one equiv. focal length (3.63″) from the easel. In the case of the 3″ lens having an equiv. focus of 2.874″, we get

$$A_2 = \frac{2.874''}{0.5''} \times \frac{180}{\pi} \times \frac{1}{10} = 32.933^\circ$$

In order to develop a cam we first select a suitable base circle on which to erect the drawing; and from experience a base circle of 4″ diameter has been found convenient to work with for lenses between 3 and 4″ focus. Having decided upon the diameter of the base circle, we next determine the length of the chord which is subtended by the angle A_2 in equation (2) which the 4″ circle, attached to the large bevel gear, turns through when the pinion advances the lens 3.63″, or one focal length from the easel. We found above that for a lens of 3.63″ equiv. focus A_2 = 41.597°; and for a lens of 2.874″ equiv. focus A_2 = 32.933°. These angles and their corresponding chords are now looked up in tables giving chord lengths for circles of unity radius; or if tables are not handy the chord lengths may be computed quite readily from the formula: chord = diameter of base circle multiplied by sin $\frac{1}{2}A_2$. The length of the chord on a base circle of 2″ radius corresponding to 41.957° is found to be 1.43″ and for 32.933° it is 1.134″. That is, each time the pinion is turned through $1\frac{1}{6.32}$ revolutions, or the linear distance necessary to advance the auxiliary base one focal length of 3.68″, the base circle turns through an angle whose chord is 1.43″; and for a lens of 2.874″ focus, the chord is 1.134″. To obtain the chord length for any other focus it is only necessary to replace *a* in equation (2) by the value representing the focus of the lens to be used. Equation (2) reduced to its simplest terms is

$$A_2 = a \times 11.459^\circ.$$

The factor 11.459° multiplied by any equiv. focal length gives the angle through which the base circle turns for each degree of enlargement. This simple formula holds good, however, only so long as the radius of the pinion remains ½″ and the gear reduction between the pinion and the large bevel gear remains 1–10.

Development of the Cam. The first step is to draw accurately a 4″ circle (see Fig. T) on a sheet of drawing paper or bristol board. The radius $O\text{–}D^1$ is drawn and extended as OD^1E. A pair of drafting dividers are now set for the distance 1.43″ and this distance stepped off around the circumference of the base circle, starting at D^1, eight times, because the apparatus has been designed to give a maximum enlargement of 8X. These eight divisions are D^1, D^2, D^3 . . . D^8.

It is necessary at this point to derive another formula before the development of the cam may be completed. We already know the rule for finding the distance of the negative from the lens for any degree of enlargement. It is: $\frac{a}{n} + a$, where a is the equivalent focus of the lens and n the degree of enlargement. These distances must now be combined with distances measured on radii of the cam in such a way as to make the cam function correctly. The simplest case to consider first is where the enlargement is the same size as the original. From the formula just given, negative distance = $\frac{3.63''}{1} + 3.63'' = 7.26''$. Suppose we start with one degree of enlargement, or where the negative distance is conjugate with the easel distance. The base circle of the cam is 4″ in diameter; therefore, the center of the cam is 2″ in advance of the distance just found. If we now rack out the auxiliary base we find the distance between the lens and the easel increases but no change takes place in the negative distance because the cam is still a circle. Next suppose we move the auxiliary base out until the distance between the lens and easel corresponds to a 2X enlargement. The negative must be pushed away from the periphery of the base circle of the cam a sufficient distance to satisfy the above formula for negative distance, which, for a 2X enlargement would be $\frac{3.63''}{2} + 3.63'' = 5.445''$. But as the cam is still a circle, its true radius is $7.26'' - 5.445''$ or 1.815″ too short; or the particular radius which is in contact with the stud on the negative carrier is 1.815″ plus the radius of the base circle, which gives as the total distance 3.815″. In other words, the distance from the center of the cam O, Fig. T, to the point on the periphery of the cam corresponding to a 2X enlargement should be 3.815″. In a like manner the distance for 3, 4 . . . 8 degrees of enlargement may be computed. Expressed as a formula it takes the following form:

$$R = (a + \text{radius of cam circle}) - \frac{a}{n}$$

where R is the radii of the cam for any degree of enlargement, a the equiv. focus, and n the degree of enlargement. For example, to find R for a 2X enlargement:

$$R = (3.63 + 2'') - \frac{3.63''}{2}$$
$$= 5.63'' - 1.815''$$
$$= 3.815''$$

N.B. The term (a + radius of cam circle) remains constant throughout the computation for various values of R.

See the Table of Radii. It now becomes an easy matter to develop the contour of the cam. The eight radii corresponding to the eight primary divisions of the cam are first computed from the formula just given. These distances are tabulated in the accompanying table and are shown in bold-faced type.

If we were to connect these points by straight lines we should obtain a very broken curve representing the contour of the cam; and as the end of each radius touched the stud on the negative carrier the negative distance for that particular degree of enlargement would be correct, but not so for intermediate points. For this reason we must compute enough points so when a contour curve is drawn through them a smooth curve is produced which makes the negative distance correct no matter what point on the periphery the cam is touching the stud attached to the negative carrier. It is to be noted from this tabulation the greatest change in the contour of the cam takes place in the lower degrees of enlargement; i. e., the lengths of the radii of the cam increase most rapidly in the smaller degrees of enlargement. Because of this it is desirable to obtain quite a few points between the first two or three primary divisions of the cam in order to draw a very smooth curve. Points corresponding to each 10th degree of enlargement up to 2.5 degrees of enlargement and by quarters for the balance of the base circle will produce a very smooth curve. These values for R for the 3 and 3½″ cams are given in the accompanying table.

Having computed all the values for R we may now complete the layout of the cam. With O, Fig. T, as a center draw the arc EFG. Divide the sector EF up into 10 equal parts, and FG, which is just one-half of EF into 5 parts. Draw partial radii through these points as indicated by 1.1, 1.2 . . . 2.5 which represent degrees of enlargement or fractions thereof. The balance of the primary divisions are divided into quarters as indicated by 2.75, 3.0 . . . 8.0.

Referring now to the table giving the lengths of these radii, we measure these distances, for each degree or fraction of a degree of enlargement, on the corresponding radii of the drawing, making all measurements from the outside edge of the base circle, first deducting 2, the radius of the base circle, from the values in the table. The distances given have been computed for the total length from the center of the base circle to the periphery, but more accurate measurements are possible by making them from the outside edge of the base circle; therefore it is necessary to subtract 2 from each of the values given in the table. A diagonal scale, divided into 10ths and 100ths of an inch will be found convenient for this purpose. Mark each point with a dot, and inclose it in a small circle for ready identification. When all the points have been laid off, the curve may be drawn through them, starting at D^1.

The foregoing method of developing a cam has been confined to a 3½″ cam. The same procedure is to be followed, however, for the 3″ cam, substituting the 3″ cam values for the 3½″ values whenever necessary. A lens of any other equiv. focus may be utilized but in this case it will be necessary to work out the values for R, the cam radii, from the formula given. When checking up the drawing in Fig. T, the measurements should be made from the outside edge of the base circle to the outside edge of the contour of the cam. The 3½″ cam is indicated by a heavy outline, and the points locating the curve inclosed by large circles; the 3″ cam is indicated by a light outline and by small circles.

Chester A. Kotterman

TABLE OF RADII FOR 3 AND 3½″ CAMS

n	R for 3″ cam .$a = 2.874''$	R for 3½″ cam .$a = 3.63''$
1.0	**2.00″**	**2.00″**
1.1	2.26	2.33
1.2	2.48	2.61
1.3	2.66	2.48
1.4	2.82	3.04
1.5	2.96	3.21
1.6	3.08	3.36
1.7	3.18	3.50
1.8	3.28	3.62
1.9	3.36	3.72
2.0	**3.44**	**3.88**
2.1	3.51	3.90
2.2	3.57	3.98
2.3	3.62	4.05
2.4	3.67	4.12
2.50	3.72	4.18
2.75	3.83	4.31
3.00	**3.92**	**4.42**
3.25	3.99	4.51
3.50	4.05	4.59
3.75	4.11	4.66
4.00	**4.15**	**4.72**
4.25	4.20	4.78
4.50	4.24	4.82
4.75	4.27	4.86
5.00	**4.30**	**4.90**
5.25	4.33	4.94
5.50	4.35	4.97
5.75	4.37	5.00
6.00	**4.39**	**5.02**
6.25	4.41	5.05
6.50	4.43	5.07
6.75	4.45	5.09
7.00	**4.46**	**5.11**
7.25	4.48	5.13
7.50	4.49	5.15
7.75	4.50	5.16
8.00	**4.51**	**5.18**

Notes and Comment

Amidol Tank Developer. In reply to a request for a reliable formula for an amidol tank developer, G. Gennert, of New York, importer of the well known Hauff developers, sends me the following formula, as used by professional finishers. It gives clean, snappy negatives and will retain its working qualities for at least a week. Dissolve 15 ounces sodium sulphite (cryst.) and 1½ drams sodium bisulphite in 15 gallons of water, adding 23 grains potassium bromide. When complete solution is obtained, add 3¾ ounces of Amidol-Hauff and the developer is ready for use.

Turner-Reich Lenses, the Pancratic Telephoto, Corona Cameras and the new Radar F:4.5 anastigmat are described and illustrated in the 1923 catalogue issued by the Gundlach-Manhattan Optical Co., Rochester, N. Y. Two "soft-focus" lenses made by this firm are worth noting: the Hyperion Diffusion Portrait Lens F:4, a convertible with single combinations of F:5.6 and F:11 offering choice of 3 focal lengths, and the Achromatic Meniscus F:6, offering a flat-field soft-focus lens of unusual focal length at extremely moderate prices.

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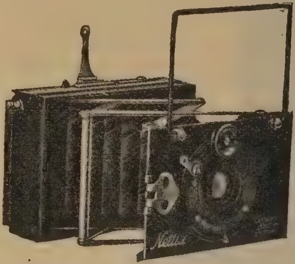

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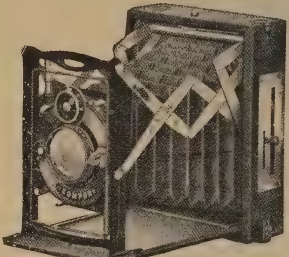
Duchessa	Citonar	F6.3	Compur	47.50
Duchessa	Teronar	F5.4	Compur	57.50
Duchessa	Zeiss Tessar	F6.3	Compur	72.50
Duchessa	Zeiss Tessar	F4.5	Compur	77.50



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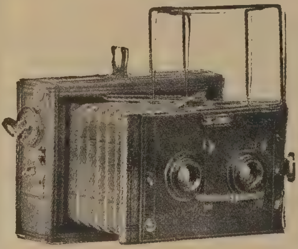

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Nettar	F6.8	Derval	30.00	35.00
Citonar	F6.3	Derval	32.50	40.00
Teronar	F5.4	Compur	52.50	60.00
Z-Triotar	F6.3	Compur	57.50	65.00
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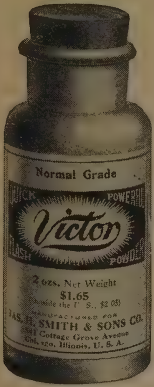

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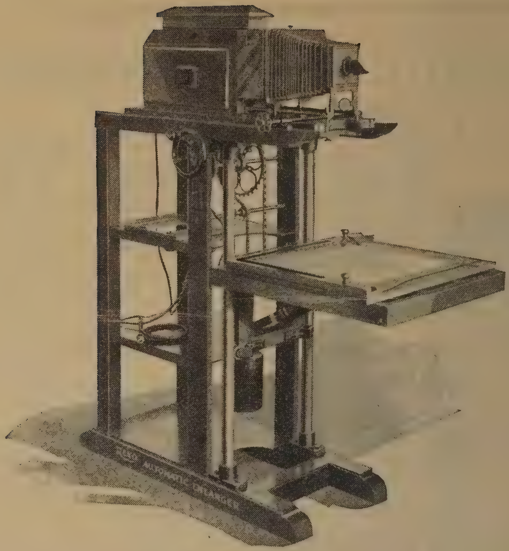

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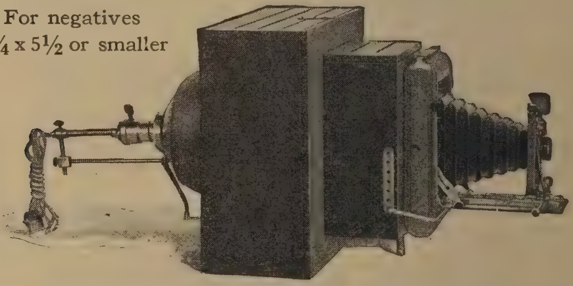

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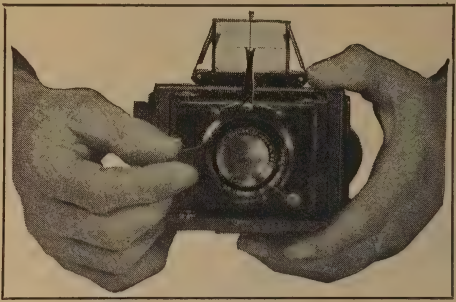

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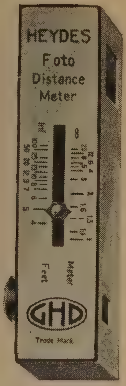

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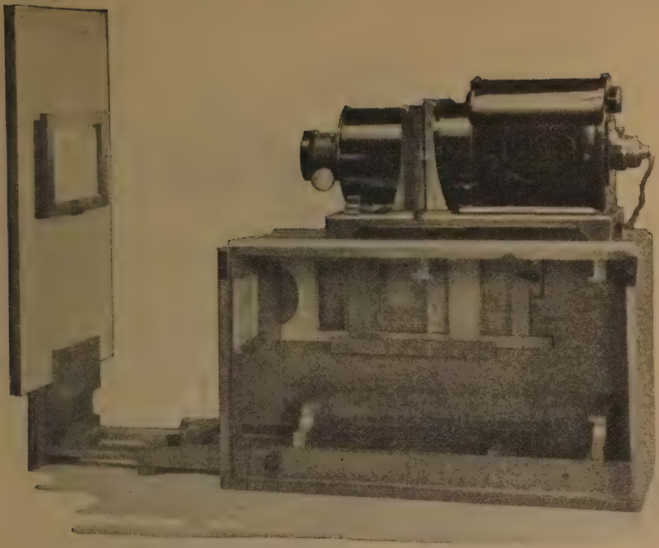

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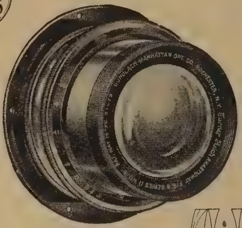

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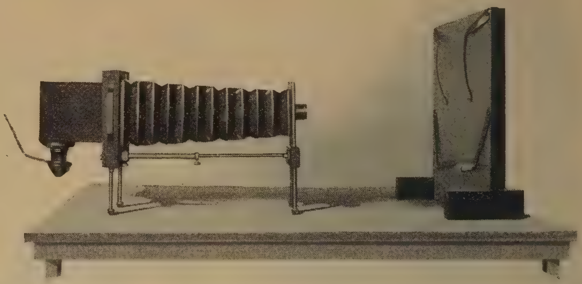

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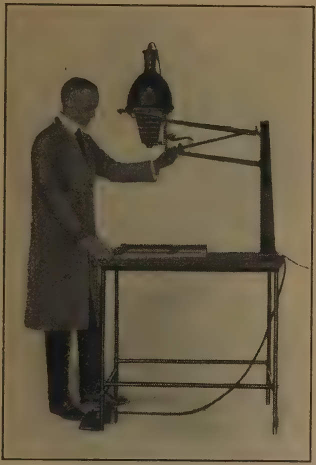

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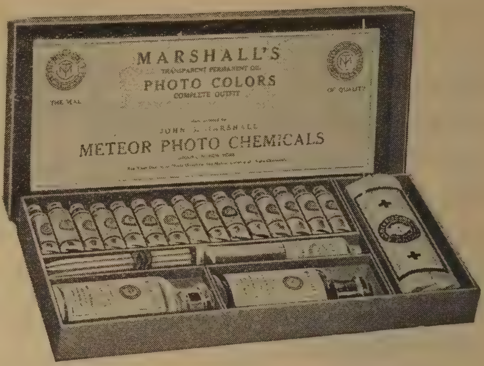

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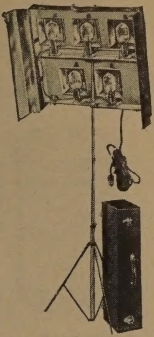

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